

**ADMINISTRATIVE INFORMATION**

1. **Project Name:** Wireless and Sensing Solutions Advancing Industrial Efficiency
2. **Lead Organization:** Honeywell Laboratories  
3660 Technology Dr.  
Minneapolis, Minnesota 55418
3. **Principal Contact:** Steve Huseth  
(612) 951-7340  
steve.huseth@honeywell.com
4. **Project Partners:**

Adcon	Hans Van Leeuwen
Air Products	Frank Schweighardt
B4HI	Peter Fuhr
Cavition Inc	David Kellner
Chevron Texaco	Albert deBeer
DowChemical	Rob DuBois
DuPont	Joseph Andrisani
Ember	Brent Hodges
EPRI	Ramesh Sankar
ExxonMobil	Paul Hromdka
Honeywell SM	Nelson Lytle
NIST	Kang Lee
NTRU	William Whyte
Omnex	Ake Severinson
CPAC, Univ of Wash	Brian Marquardt
UOP	Michelle Cohn
5. **Date Project Initiated:** September 1, 2003
6. **Expected Completion Date:** December 31, 2007

**PROJECT RATIONALE AND STRATEGY**

7. **Project Objective:** The Honeywell Team will develop, demonstrate, and test a number of leading edge technologies that will enable the emergence of wireless sensor and sampling systems for the industrial market space. This effort combines initiatives in advanced sensor development, configurable sampling and deployment platforms, and robust wireless communications to address critical obstacles in enabling enhanced industrial efficiency. This effort consists of 3 components. The first element of this effort will develop and demonstrate innovative technology for preconcentrating and composition analysis of gaseous process streams (PHASED). Sampling and composition sensing technologies are viewed as the weak links in process control and automation and are widely identified as a crosscutting and recurring need for the Industries of the Future (IOF). The developments produced by this project will directly lead to reduced process upsets, reduced energy consumption and reduced environmental emissions, as well as enhanced economic competitiveness. The second element of the project will demonstrate a new modular, networked, intrinsically safe and industry accepted standardized process stream sampling and microanalytical system (NeSSI) that will also be extended and tested in operational process plant environments to validate its suitability for a spectrum of industrial process applications. Finally, an industrial wireless

sensor communication network architecture will be designed, developed, and tested in operational environments that will offer a level of robustness and reliability not available in current wireless sensors systems leading to the opportunity for broader market acceptance of wireless solutions. The goal of the sensor network is to enable "pervasive sensing" for industries and factories to cost-effectively obtain increased levels of energy and operating efficiency through lower cost access to enhanced monitoring and information analysis.

8. **Technical Barrier(s) Being Addressed:** Relative to bulky, slow, and carrier-gas requiring conventional GCs, PHASED represents a significant leap forward. This unique approach provides reduced size (NeSSI-compatible), short analysis time (1-2 seconds), no carrier gas requirement, low-cost, and low-power (2-5 W) for compositional analysis of process streams, air quality, or fugitive emissions. Compactness, speed and low-power use is provided by leveraging micro-structure integration of preconcentration, separation and orthogonal detectors to improve peak identification. The development of smart, plug-and-play components for NeSSI, enables each component to be recognized as soon as it is plugged in and subsequently validated or rejected (fault diagnosis) as appropriate. The new components will be IS-certified and can be easily exchanged w/o purge or shutdown precautions.

Industrial wireless sensor networks have obtained limited acceptance due to high cost, non-deterministic and unreliable performance, and setup and installation complexity. Real or perceived fear of the loss of the sensor data has prohibited wireless sensors from being used in advanced control situations. Instead they have been largely marginalized to simple monitoring applications rather than critical process control. To reduce power requirements and increase reliability, mesh networks have gained acceptance for their ability to reroute messages through intermediate nodes when a primary communication path fails. This however does not address the fact that critical control information is highly time sensitive. Critical data must be guaranteed to not be lost but also must arrive within a very narrow time window. Rerouting messages around failed nodes can affect the delivery of other messages being transmitted through the entire network. The use of unlicensed frequency bands requires products that are intended to be used globally adhere to the lowest common denominator of local country requirements of frequency range and power resulting in suboptimal solutions. Each of these risks and barriers will be address in the course of the project.

9. **Project Pathway:** The PHASED Micro-GC analyzer is based on MEMS (i.e., silicon-micromachined chip) technology and features innovative valveless pre-concentration and injection. The GC column consists of etched channels integrated with an array of heatable elements. An analysis cycle begins in the pre-concentrator with a traveling temperature wave that drives adsorbed analyte molecules toward the separator stage, which is temperature-programmed like a conventional GC, and finally to the differential thermal conductivity detector (TCD) and additional detectors also on-chip. The column adsorber films are supported by low thermal mass membranes, which reduce analysis time to 1-3 seconds and the energy requirements to as low as 10 J/analysis.

The NeSSI platform will accommodate about 40 standard component slots (ANSI SP-76) through a standardized, low cost, compact and flexible building-block arrangement. The low-power, IS-certification, plug-and-play, component networking, and the "combi valve" (air-powered valve with digital control) features are key innovations. Such sampling/sensor systems would be widely applicable across the processing industries, and with an "open" architecture would meet known functional needs. The objective of including the above key hardware elements and functions is to provide users with versatile software for control of the sampling/calibration stream. Honeywell proposes to implement a solution that addresses its control capabilities. The NeSSI platform will interface via an accepted communication such as Profibus with the SAM (Sensor-Actuator Manager)

for the NeSSI components), which will also interface with the higher-level systems within the plant via OPC over Ethernet, or via wireless.

The wireless network development will proceed with an extensive Voice of the Customer analysis followed by a detailed requirements analysis reflecting the specific needs of the industrial marketplace and an identification of the critical feature sets required to catalyze the market. Multiple wireless components using existing commercial solutions will be evaluated for elements of robustness, interference rejection, and low-power consumption. These elements will be combined into a network architecture that will ensure robustness and reliability of the entire system. Specific requirements from the industrial systems market that are unique and distinct from adjacent markets such as small buildings and homes where traditional lower cost and less reliable solutions are used will be integrated into the final system where possible. Operational components will be developed suitable for installation and testing in operational industrial environments and will be installed and tested to ensure that critical requirements for the industrial market space are met. Critical to the success of the program is to ensure the solution is widely acceptable to the marketplace and available from multiple sources. Industry organizations such as WINA and ZigBee will be critical to the success of the approach to ensure broad applicability.

10. **Critical Technical Metrics:** This effort will demonstrate an analysis capability for low to medium molecular weight gas mixtures, down to the 0.01 to 1 ppm level, within 3 seconds, w/o carrier gas, and with energies of less than 10 J/analysis. It will also demonstrate the operation of an industrial-grade rugged version of PHASED that is compatible with NeSSI-III fluid-sampling and electronic interfaces and achieve sufficient resolution to analyze 10-20 analytes in one analysis. End User participants from across the processing industries will develop applications and field test NeSSI-II/-III systems that will save energy via reducing the number of process upsets and the amount of product waste and via increasing process efficiency while reducing life cycle cost of sampling and analytical hardware. The wireless infrastructure must be capable of showing significant immunity to intentional and unintentional jamming from nearby RF devices while providing a communication range of several miles and battery life of several years. It must also be capable of coexisting with other preexisting RF devices that are in use within the facility. The system must be supported by a highly secure, easy to use strategy for distributing security keys throughout the system and achieve a near "hacker proof" communication infrastructure.

## **PROJECT PLANS AND PROGRESS**

11. **Past Accomplishments:** Not applicable, projects initiated in FY04

12. **Future Plans:**

- a. Complete Voice of the Customer interviews at key industrial locations on wireless sensing applications and solutions. Integrate results into a System Requirements Specification that will be used to drive the emerging design details. Planned completion 5/30/2004
- b. Complete design, documentation, and demonstration of multiple independent wireless components demonstrating elements of security, robustness, reliability, and power consumption. Planned completion 12/30/2004
- c. Design and integrate a version of PHASED suitable for industrial-grade ruggedness, reduced power consumption, with on-chip detectors. Test and characterize the performance via lab tests of devices with a number of test gases such as house nitrogen, room air, natural gas, and special test gas mixtures. Planned completion 12/30/2004
- d. Complete production-ready versions of integrated wireless system components and install into field test environments. Planned completion 6/30/2006

- e. Field test and evaluate the PHASED sensor on NeSSI at user sites. Planned completion 6/30/2006

13. **Project Changes:** None

14. **Commercialization Potential, Plans, and Activities:** Honeywell is considering a number of possible commercialization paths. As a leading, world-wide supplier of process control system integration and project engineering services, Honeywell Industrial Solutions has a direct global distribution channel to introduce wireless technologies, sensors and systems across a number of industrial markets. Honeywell's Sensing and Control and Industrial Measurement and Control units will use direct sale, distributor and indirect distribution channels to distribute wireless components and sensors to industrial end users world wide. Several of our subcontractors are already providing products to the current industrial wireless market through their own distribution channels and are well-positioned to drive the new wireless technologies into new markets, including companies that compete directly with Honeywell.

15. **Patents, Publications, Presentations:** PHASED preconcentration and microanalytics